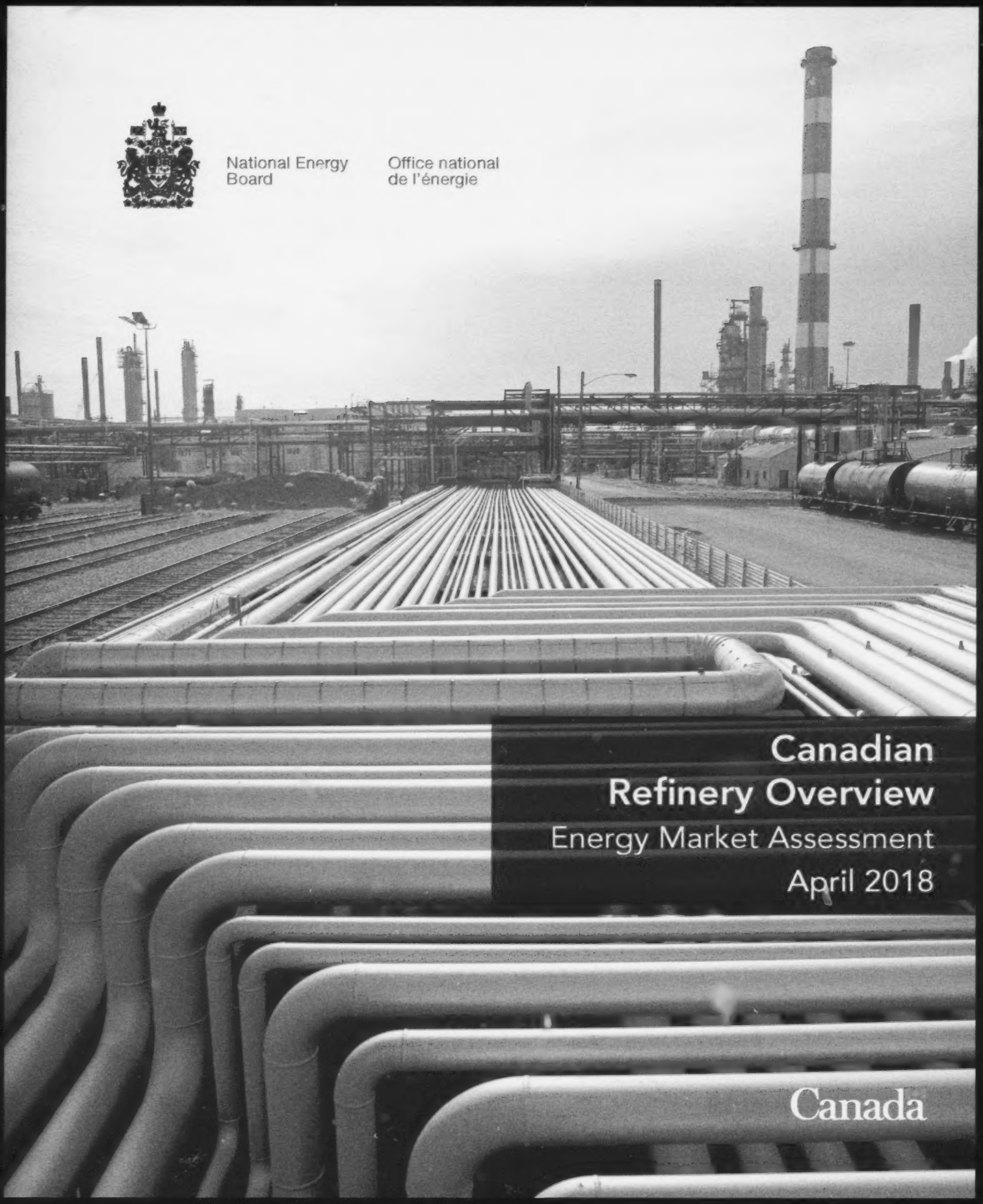

National Energy Board

Office national de l'énergie

Canadian Refinery Overview

Energy Market Assessment

April 2018

Canada

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Energy Market Assessment

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Aperçu des raffineries au Canada en 2018 –
Évaluation du marché de l'énergie.

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Ce rapport est publié séparément dans les deux langues officielles. On peut obtenir cette publication sur supports multiples, sur demande.

About the NEB

The National Energy Board (NEB or Board) is an independent federal regulator. Its purpose is to promote safety and security, environmental protection, and economic efficiency in the Canadian public interest within the mandate set by Parliament for the regulation of pipelines, energy development, and trade.

The Board's main responsibilities include regulating:

- the construction, operation, and abandonment of pipelines that cross international borders or provincial/territorial boundaries;
- associated pipeline tolls and tariffs;
- the construction and operation of international power lines and designated interprovincial power lines;
- imports of natural gas and exports of crude oil, natural gas, oil, natural gas liquids, refined petroleum products, and electricity; and
- oil and gas exploration and production activities in specified northern and offshore areas.

About this Report

The Board monitors energy markets and assesses Canadian energy requirements and trends to support its regulatory responsibilities. This report, Canadian Refinery Overview 2018 – Energy Market Assessment, is part of a portfolio of publications on energy supply, demand, and infrastructure that the NEB publishes regularly as part of its ongoing market monitoring.

Contributors to this report include: Colette Craig (project manager), Grant Moss.

Questions or comments? Please e-mail energy-energie@neb-one.gc.ca.

Table of Contents

Executive Summary 1

What is a Refinery? 2

Refinery Profitability 3

Canada's Refineries 4

Crude Oil Pricing and its Impact on Canadian Refineries 6

Crude Oil Receipts and Refining Capacity 7

Refining Capacity 7

Refined Petroleum Product Supply and Demand Balance 9

Refineries by Region 11

Western Canada 11

Central and Atlantic Canada 12

Ontario 12

Quebec and Atlantic Canada 14

Crude Oil Imports to Central and Eastern Canada 15

Executive Summary

Canada is the world's seventh largest crude oil producer[1] and has the world's third largest crude oil reserves. It has a strong refining industry, ranking 11th in the world in capacity. Despite being a top ten producer of crude oil, and having a strong refining industry, Canada processes only a fraction of its own crude oil production. Most of the refineries in Canada, built when there were abundant supplies of light crude oil, were not configured to process growing volumes of heavy crude oil from the oil sands. Canadian refineries have imported significant volumes of crude oil, mostly light, because not all refineries have had access to western Canadian crude oil.

Refineries, including those in Canada, are generally located on major waterways, near crude oil production or near major population centres. Location is important because it determines both where a refinery sources its crude, and the type of crude oil it processes.

Canada has 14 full refineries and 2 asphalt refineries. Canada's total refining capacity is 295 thousand cubic metres per day ($10^3m^3/d$) or 1.9 million barrels per day (MMb/d) (Figure 3). Quebec and Atlantic Canada have the most refining capacity at 124 $10^3m^3/d$ (782 thousand barrels per day (Mb/d)), followed by western Canada at 109 $10^3m^3/d$ (683 Mb/d) and Ontario at 62 $10^3m^3/d$ (390 Mb/d).

Canadian refineries produce refined petroleum products (RPPs) including gasoline, diesel fuel, jet fuel, heating oil and others. Canada's RPP production is primarily for domestic consumption, with some exports mainly from the Atlantic refineries.

Refineries east of the Prairie Provinces process primarily conventional light crude oil. Refineries in western Canada process more oil sands crude than refineries in eastern Canada. The reversal of Enbridge Line 9, back to its original eastward flow, has connected western Canadian crude oil supply with Montreal refineries and allowed more to flow to Ontario. This was an important market development for both crude oil producers and refiners. It gave producers an additional market for their production and it gave refiners pipeline access to relatively less expensive western Canadian crude oil.

Although Canadian refineries are processing more Canadian crude than ever before, eastern Canadian refineries will still import crude oil to meet their refining needs. This will expose them to the international crude oil market, more so than refineries in western Canada.

1 Behind Russia, Saudi Arabia, United States (U.S.), Iraq, Iran, and China.

What is a Refinery?

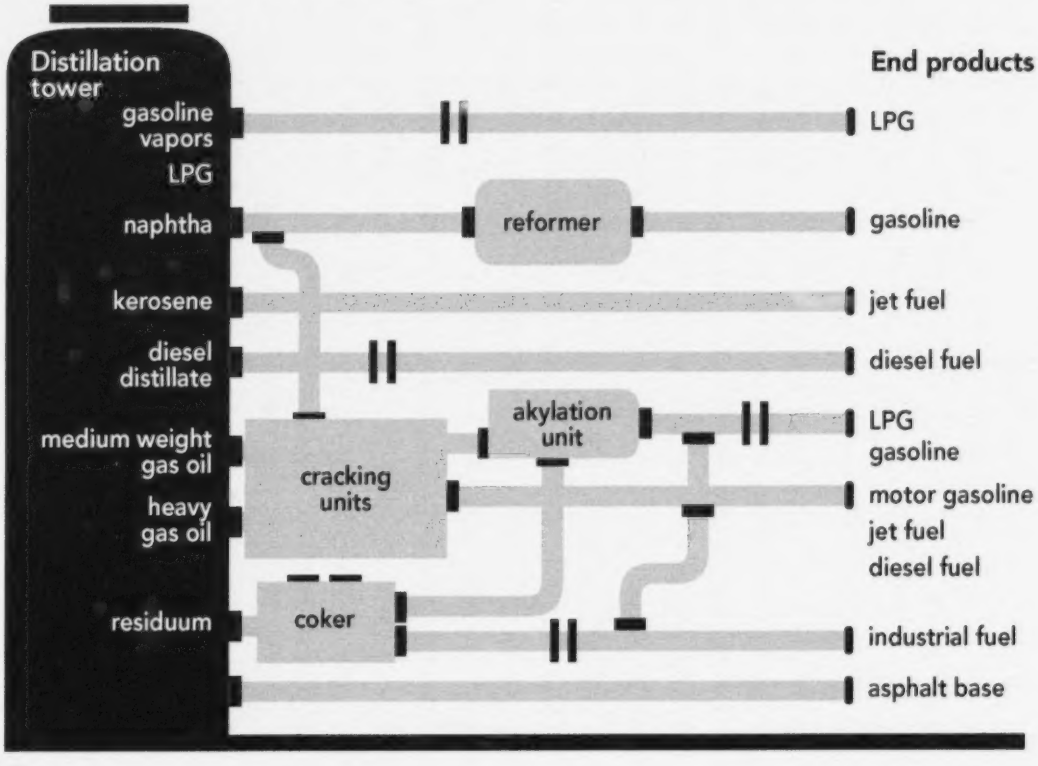
A refinery processes crude oil into RPPs such as gasoline, diesel fuel, jet fuel, and heating oil, as well as liquid petroleum gases (LPGs) such as propane and butanes. Approximately 80% of the products produced in a refinery are used to either move people and goods, or keep people warm. The other 20% includes inputs into the petrochemical industry, as well as kerosene and stove oil, asphalt and lubricating oil and greases, to name a few.

Crude oil is a mixture of many individual hydrocarbons, each of which have a unique boiling point. This property is the basis for separating the components in the distillation process, the first and most important process in the refinery.

In the first step of the refining process, crude oil is heated in a large furnace, where most of the oil boils off into a gas. The liquids and vapours are then discharged into distillation units which are specifically designed vertical towers that separate and collect fractions of crude oil components with similar boiling points. Because heavier hydrocarbons have higher boiling points than the lighter hydrocarbons they tend to fall to the bottom of the column in liquid form. At the same time, lighter components tend to rise in gaseous form to the cooler top end of the column. Components that boil somewhere in between are collected and withdrawn from the distillation tower at intermediate points in the column.

FIGURE 1

Simplified Illustration of a Petroleum Refinery



Source:
Energy Information Administration

After distillation, the heavier products can be processed in a variety of ways, all with the objective of increasing the refinery yield of higher value, lighter products like gasoline and diesel. Cracking breaks down heavier streams from the distillation process into lighter components, and is the most important conversion process in a modern refinery. It turns heavier crude oil fractions (which would otherwise have to be sold at a discount to crude) into blending components for finished products. Other refinery processes, including alkylation and reforming target improvement in the quality of specific crude oil fractions. Not all refineries have coking units, but those that do are able to process even the heaviest distillation fraction from crude oil (commonly called residue), into lighter fractions for subsequent processing and blending.

Refinery Profitability

Refineries maximize profit by maximizing yields of high value products like transportation fuels (gasoline and diesel) while minimizing shipping costs of their feedstock (crude oil) and products. Maximizing profitability is also a balancing act: a refinery can reduce the costs of its feedstock by refining heavy crude oil instead of light crude oil, because light crude oil is more expensive; however, heavy crude oil is more difficult and costly to refine, as it requires additional equipment like a coker.

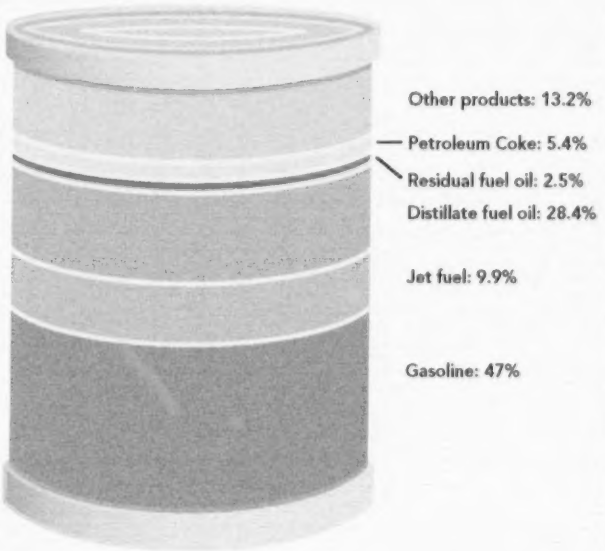
Compared to light crude oil, refining heavy crude oil typically yields higher proportions of lower value products, all else being equal.

A barrel of crude oil equals 42 U.S. gallons[2] (159 litres) and produces approximately 170 litres of RPPs when refined. (Figure 2) The outputs from refining are greater than the inputs, because most of the products they make have a lower density than the crude oil they process. This increase in volume is called processing gain. Different refineries can also produce different yields because of the structure and composition of their processing units.

Demand for RPPs, particularly for gasoline, is somewhat seasonal. In the spring, refiners maximize production of gasoline to meet increased demand during the summer driving season. There is also more asphalt produced in the summer because of increased road construction. In the fall, production of light fuel or heating oil increases because of higher heating demand during winter.

FIGURE 2

Petroleum Products Made From a Barrel of Crude Oil



Source:
Energy Information Agency Administration

What is Light Crude Oil? Generally, crude oil with low viscosity which flows freely at room temperature. There are varying thresholds for the line between light and medium crude oils. Light crude oil is also a collective term used to refer to conventional light crude oil, upgraded heavy crude oil, and pentanes plus.

What is Heavy Crude Oil? Generally, a crude oil that is very viscous and has a density greater than 900 kg/m³, or an API gravity below 25.

2 1 U.S. gallon equals 3.8 litres or .83 imperial gallons.

Canada's Refineries

Canada's total refining capacity is 295 $10^3m^3/d$ (1.9 MMb/d) (Figure 3). Quebec and Atlantic Canada have the most refining capacity at 124 $10^3m^3/d$ (782 Mb/d), followed by western Canada at 109 $10^3m^3/d$ (686 Mb/d) and Ontario at 62 $10^3m^3/d$ (390 Mb/d).

Canadian refineries have different characteristics depending on their location. Generally, refineries are located on major waterways, near major cities or near crude oil production. Being on a major waterway gives a refinery access to offshore crude oil as well as export market access for its RPPs. Being close to a large city provides a market for its RPPs and lowers the cost of transportation. Being close to crude oil production gives a refinery ample local supply at low transportation costs.

Most Canadian refineries are owned by vertically integrated companies, which have crude oil production, refining and product marketing. The refineries in western Canada have access to western Canadian crude oil production; therefore, domestic crude oil supplies meet all of their feedstock needs. The refineries in Ontario used to import crude oil from around the world to supplement their needs. However, the recent reversal of Enbridge Line 9 provided greater access to western Canadian crude oil and U.S. imports. Quebec also receives crude oil on the reversed Line 9 and processes western Canadian crude oil, as well as U.S. imports. Refineries in Atlantic Canada import most of their crude oil and process some domestic east coast production. Refineries base their crude oil purchasing decisions on access and economics. Currently, refineries in Atlantic Canada have no pipeline access to western Canadian crude oil and this is why the eastern Canadian refineries use mainly imported crude oil rather that Canadian production[3].

Refineries in western and central Canada receive the majority of crude oil via pipeline, with smaller volumes transported by rail. In Atlantic Canada, most of the crude oil is delivered by tanker with smaller volumes transported by rail.

The History of the Enbridge Line 9 and its importance to the Canadian Refining Industry

As a result of the 1973 Organization for Petroleum Exporting Countries (OPEC) embargo, the Government of Canada, concerned about the potential vulnerability of central Canadian refineries which imported crude oil, asked Interprovincial Pipeline (IPL, now Enbridge) to extend its pipeline system from the Toronto area to Montreal. In 1975, the Government entered into an agreement with IPL to construct an extension from Sarnia to Montreal. The Line had a capacity of 50 $10^3m^3/d$ (315 000 b/d).

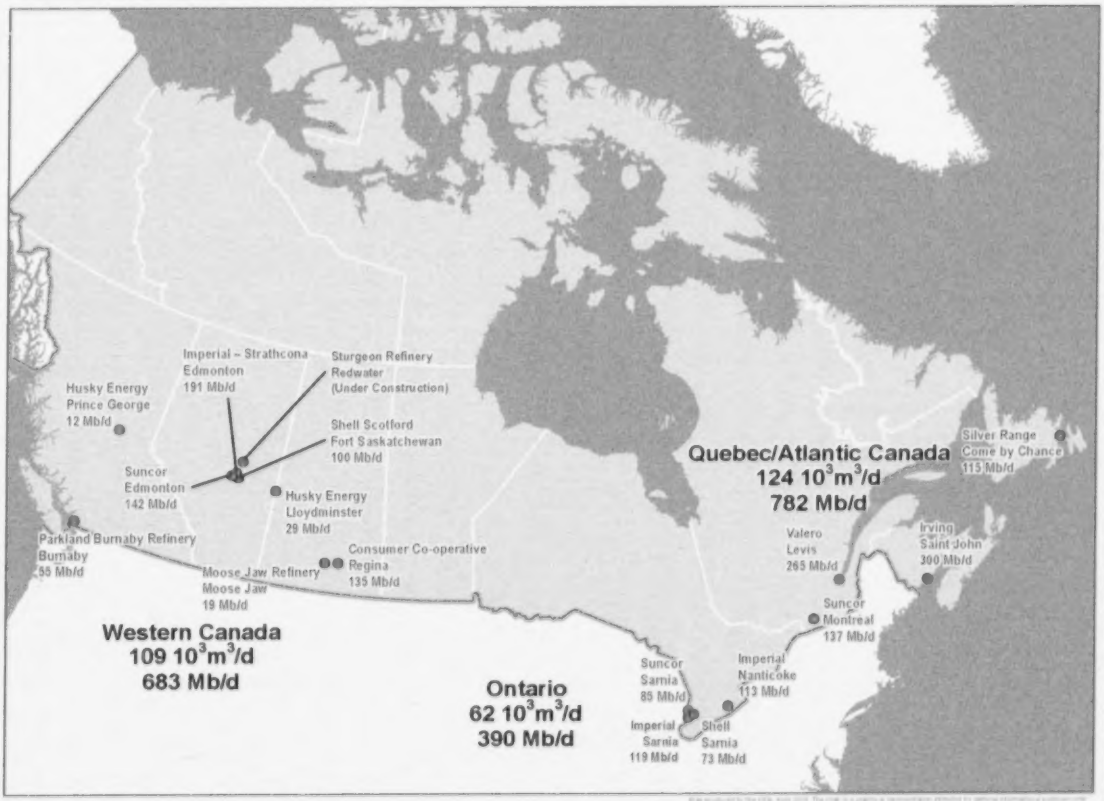
Between 1976 and 1997, Line 9 supplied refineries in Ontario and Quebec with western Canadian crude oil via Sarnia after being shipped through the U.S. In 1999, because of increased global oil supply, Line 9 was reversed allowing overseas crude oil (which was already being imported at Portland, Maine and transported on the Portland-Montreal Pipeline to Montreal refineries) to be shipped further westward on Line 9 to reach refineries in Ontario. During that time, Line 9 had a capacity of 38 160 m^3/d (240 000 b/d).

In 2011, with lower North American crude oil prices relative to imported crude oil, the line was underutilized and Enbridge applied to the Board to re-reverse a section of the pipeline between Sarnia and North Westover, Ontario. In 2013, the first phase of the Line 9 reversal was completed, allowing transport of North American crude oil to more refineries in Ontario. In 2012, Enbridge filed an application with the Board to reverse the remaining section of Line 9, between North Westover and Montreal and expand the capacity to 47 700 m^3/d (300 000 b/d). Since 2015, growing supplies of western Canadian and U.S. crude oil have been reaching refineries in Quebec.

3 Since 2010, Newfoundland and Labrador has increasingly exported more of its oil to non U.S. markets. Exports to non U.S. markets such as Europe and the Caribbean made up 8% of the province's export volumes in 2010 and increased to 21% of the province's exports in 2016.

FIGURE 3

Canadian Refineries and Capacity



Source:
Canadian Association of Petroleum Producers (CAPP)

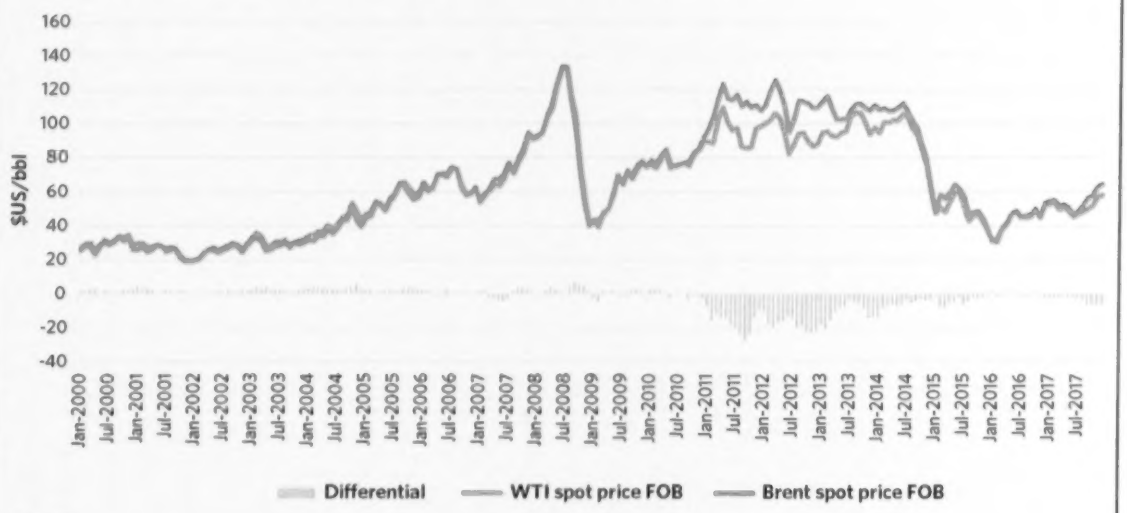
Crude Oil Pricing its Impact on Canadian Refineries

Canada imports crude oil even though it produces more crude oil than it processes in its refineries. This is because of the locations of the refineries and the type of crude oil that is produced in Canada. As a result, some refineries process both domestic and imported crude oil. Canadian refineries that process imported crude oil are exposed to global crude oil prices which are higher at times than North American prices. Between 2000 and 2010, West Texas Intermediate (WTI), which is the benchmark price for North American crude oil, averaged $1.40/bbl higher than the price for Brent, which is the international benchmark price. (Figure 4)

In 2011 and 2012, rising crude oil production in the U.S. and limited export access for North American crudes caused the price of WTI to be much lower than Brent. The differential averaged almost US$17/bbl, and reached as high as US$27/bbl in September 2011.

FIGURE 4

Spot Price of West Texas Intermediate and Europe Brent



Source:
Energy Information Administration

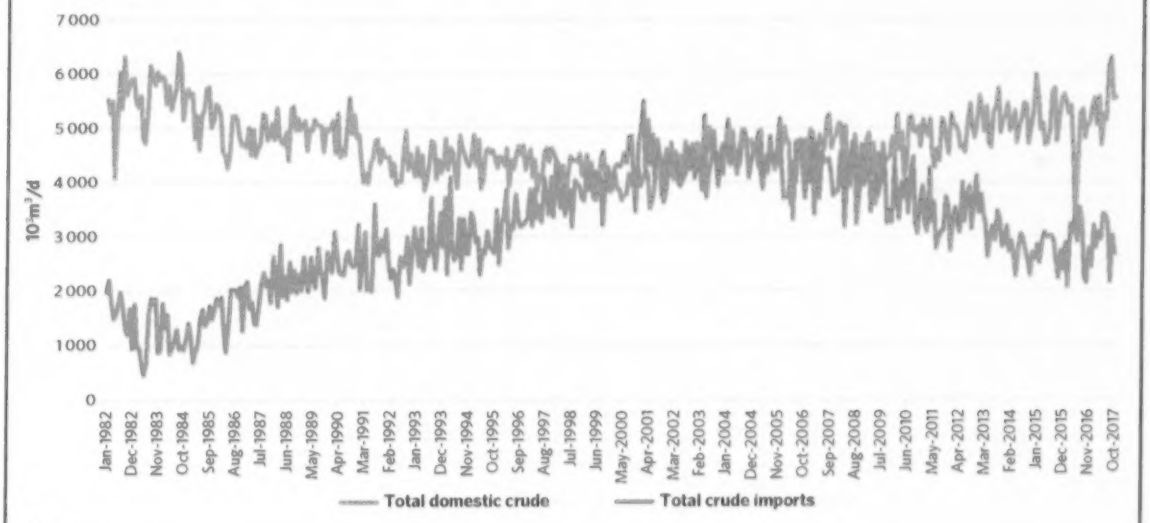
Refineries in Ontario, Quebec, and Atlantic Canada which import light crude oil priced at Brent, saw their crude oil costs rise compared to those refineries in western Canada and the U.S., with access to less expensive, western Canadian or midcontinent North American crude oil.

Crude Oil Receipts and Refining Capacity

A refinery purchases crude oil to consume in its refinery or to store for later use. These are crude oil receipts. Between 1982 and 2004, refinery receipts of imported crude oil grew, while domestic crude oil receipts declined. During this time, the refining profit from running offshore crude oil rather than domestic crude oil was favourable. That meant that many of the refineries in Canada were importing crude oil. In 2005, this started to change. Imports began to fall and domestic crude oil volumes rose slightly. (Figure 5) In 2010, this trend became more pronounced because the difference in the cost of North American crude oil and offshore crude oil was significant. The closure of refineries in central and Atlantic Canada that imported crude oil, the economic use of rail to transport discounted domestic crude oil and the re-reversal of Line 9 also contributed to this trend.

FIGURE 5

Crude Supply to Canadian Refineries



Source:
CANSIM 134-0001

Refining Capacity

Between 2005 and 2013, three refineries closed in central and Atlantic Canada: Imperial Oil Dartmouth (2013), Shell Montreal (2010), and Petro-Canada Oakville (2005). While the age[4] and complexity of those refineries were factors, changing environmental regulations for gasoline, overall declining demand for RPPs, and higher crude oil costs for eastern refineries have led to a broader, long-term trend of smaller refineries closing and consolidating in favour of larger, more complex ones.

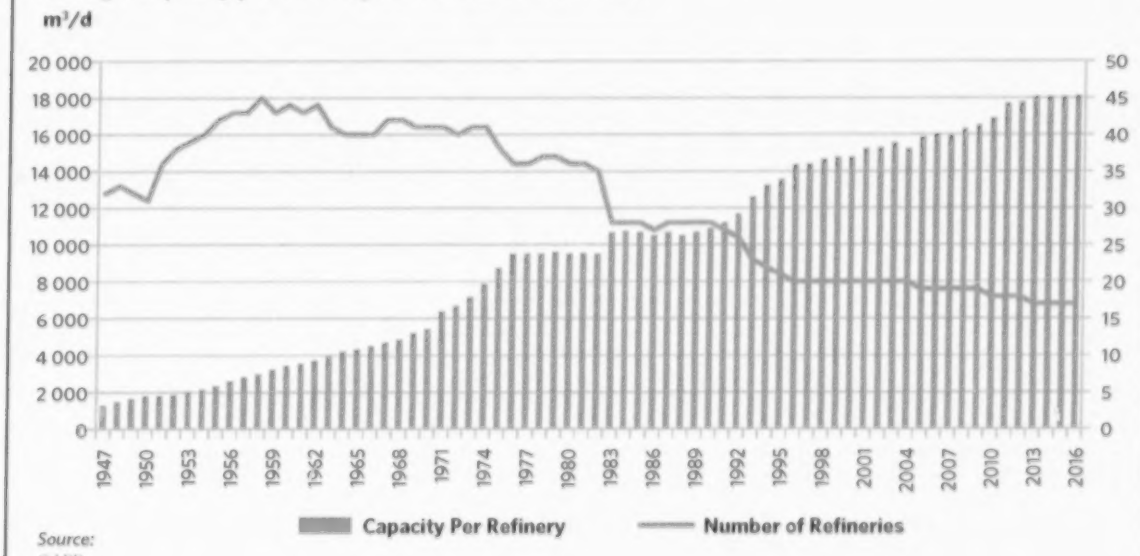
4 The Dartmouth Refinery operated for 95 years, the Shell refinery for 76 years and the Oakville Refinery for 63 years.

Despite a decline in the number of total refineries, the average capacity per refinery in Canada has increased. This indicates that consolidation has resulted in larger refineries and greater efficiencies. The average capacity per refinery in 2016, reached 18 $10^3m^3/d$ (114 Mb/d) – an all-time high. (Figure 6)

There had been no new refineries built in Canada in 30 years. However, in late 2017, the Sturgeon Refinery located northeast of Edmonton began operations.

FIGURE 6

Average Capacity per Refinery vs Number of Refineries



Source:
CAPP

The Sturgeon Refinery

The Sturgeon Refinery, located northeast of Edmonton, is owned and operated by North West Redwater Partnership. The Partnership is an alliance between North West Upgrading and Canadian Natural Upgrading Ltd., a subsidiary of Canadian Natural Resources Ltd. It is the first Canadian refinery built in 30 years.

Sturgeon is estimated to process 13 $10^3m^3/d$ (79 Mb/d) of diluted bitumen into ultra-low sulphur diesel fuel and other high-value products, including diluent.

In its first phase of operation, the Alberta government will provide 75% of the diluted bitumen feedstock and Canadian Natural Resources will supply the remaining 25%.

Source:

North West Redwater Partnership

The refinery produced its first diesel fuel in December 2017. It is still under construction and can currently only process synthetic crude oil and not bitumen.

Sturgeon is using advanced technologies to reduce environmental impacts, including a carbon capture and storage (CCS) system. The refinery will also tie into the Alberta Carbon Trunk Line that will transport CO_2 to declining oil fields in central Alberta for the purpose of enhanced oil recovery.

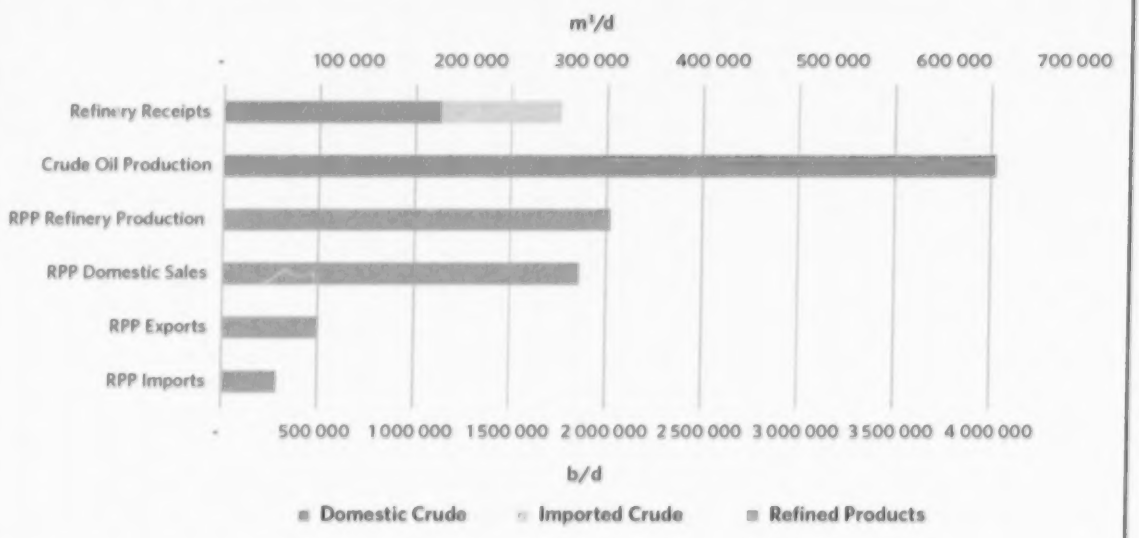
Refined Petroleum Product Supply and Demand Balance

Canada is the seventh largest crude oil producer in the world. Despite this, Canadian refineries process less than 30% of that crude oil. (Figure 7) This is mainly because of the size of Canada's refining industry compared to the resource size, the location of its refineries, and the lack of cross-country pipeline connectivity. Canadian refineries operate mostly to meet domestic needs, with some exports.

Most refineries, including those in Canada, do not operate at 100% capacity. This is mostly due to planned/unplanned maintenance and outages. In 2017, Canadian refineries operated at 84% of their capacity.

FIGURE 7

Refined Product Disposition – 2017[5]

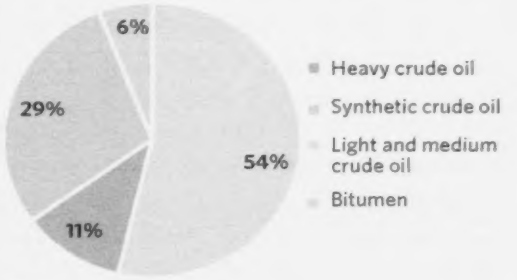


Source:
Refined Products: CANSIM 134-0004; Crude: CANSIM 134-0005; Crude Oil Production: CANSIM 126-0001

5 Year-to-Date September 2017.

FIGURE 8

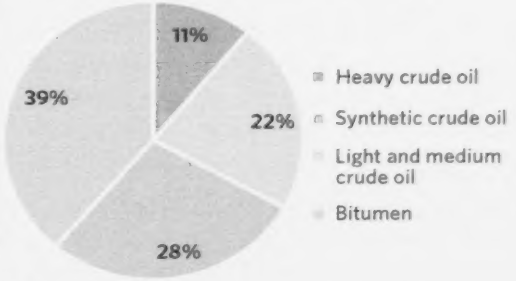
Canadian Crude Oil Receipts by Type[6]



Source:
CANSIM 134-0001

FIGURE 9

Canadian Crude Oil Production by Type[7]



Source:
CANSIM 126-0001

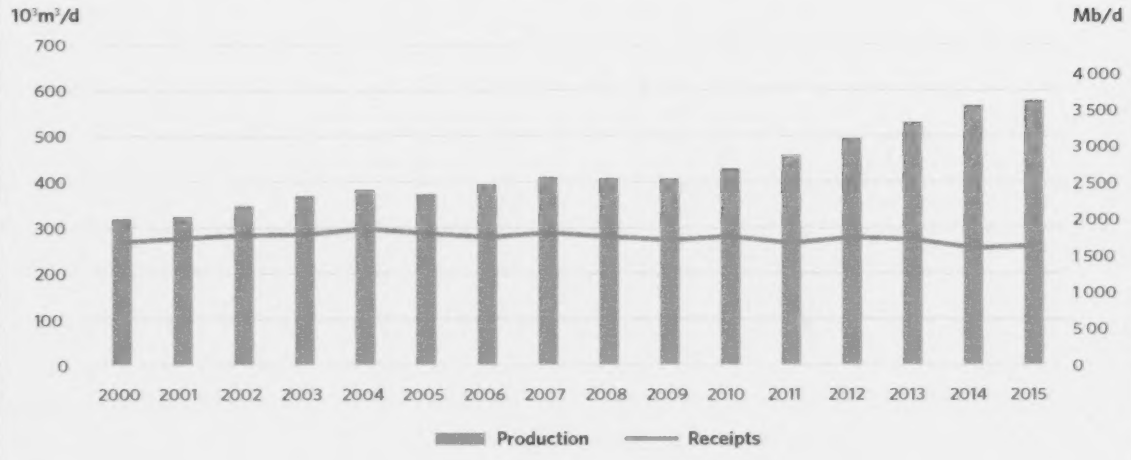
In 2017, over half of the crude oil processed in Canadian refineries was light conventional crude oil. Slightly over one-third of refinery receipts was crude oil from the oil sands (either bitumen or synthetic). (Figure 8) The rest is conventional heavy oil.

In 2016, almost 40% of Canadian production was crude bitumen, followed by synthetic, light and medium, and heavy crude oil. (Figure 9).

Figure 9 shows that bitumen accounts for almost 40% of Canadian production while making up less than 10% of total crude oil refined in Canada. Canada exports most of its bitumen production to the U.S.

FIGURE 10

Canadian Crude Production vs Refinery Receipts



Source:
Production: CANSIM 126-0001 and Receipts: CANSIM 134-0004

Crude oil receipts at Canadian refineries have not grown since 2000; however, Canadian production has increased. (Figure 10) Canadian refinery production peaked in 2004. Between 2004 and 2015, refinery production dropped nearly 15%.

6 Year-to-Date January to October 2017.
7 Average January and February 2016.

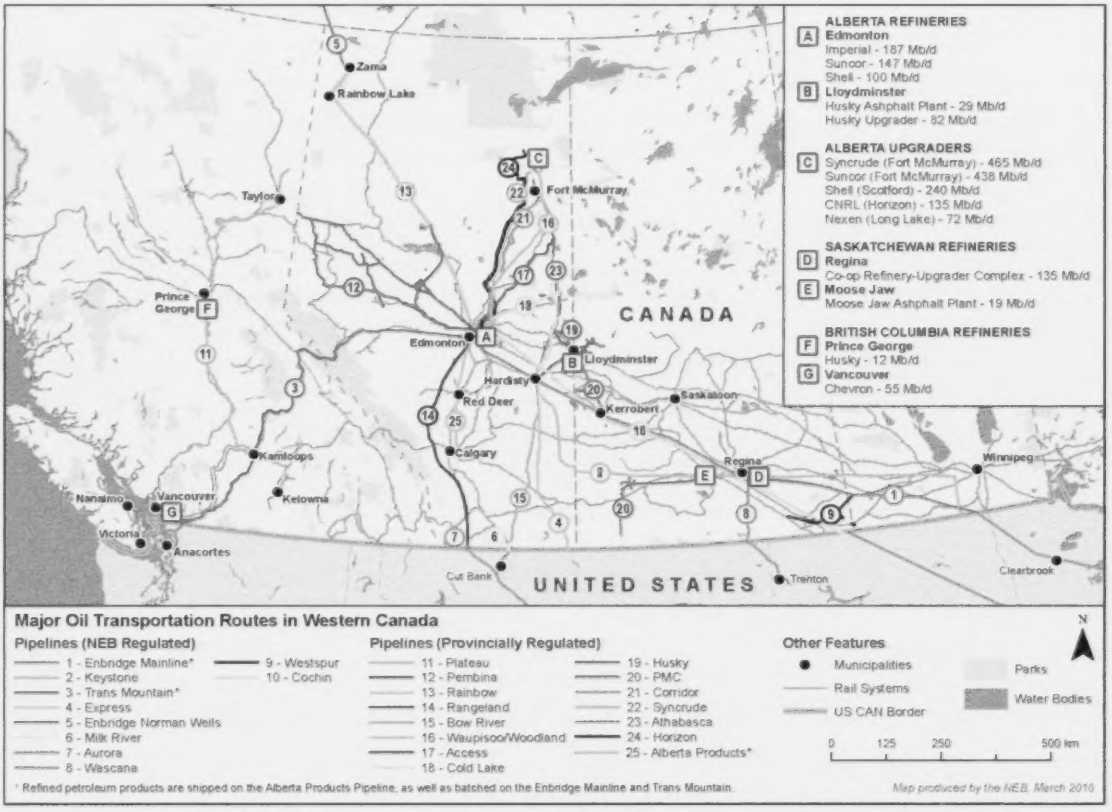
Refineries by Region

Western Canada

Most refineries in western Canada are owned by vertically integrated companies, which have crude oil production, refining, and product marketing. The refineries in western Canada have access to western Canadian crude oil production and domestic crude oil supplies meet all of their feedstock needs. As shown in Figure 11, refineries in western Canada are well connected to local crude oil production by pipeline systems. These refineries use western Canadian crude oil because it is close. This is advantageous relative to other Canadian refineries because their facilities produce products at a lower cost. If and when possible, integrated companies even process their own crude oil production.

FIGURE 11

Western Canada – Refineries and Major Oil Transportation Routes



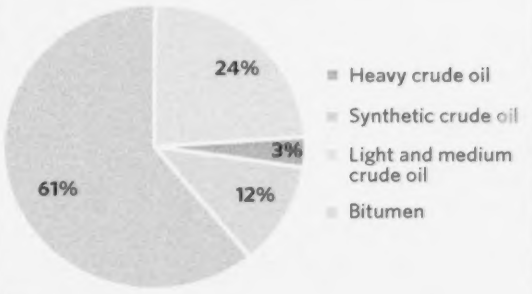
Refineries in Alberta and B.C. process more oil sands crude, synthetic and bitumen, than other refineries in Canada. (Figure 12) B.C. refineries source crude oil from B.C. as well as from Alberta on the Trans Mountain Pipeline.

Western Canada is connected with refined product pipelines. Within Alberta, RPPs are transported from Edmonton on the Alberta Products Pipeline to the southern part of the province. Refined petroleum products are transported to B.C. via the Trans Mountain pipeline and to Saskatchewan, Manitoba and northwestern Ontario on the Enbridge Mainline.

However, Alberta has limited access to RPP imports. In general, the Prairie Provinces cannot easily meet their RPP demand in the event of a disruption because they do not have the capacity to bring in large quantities, by pipeline or other means, from other regions.

FIGURE 12

Input to Refineries by Crude Type – Alberta and British Columbia[8]



Source:
CANSIM 126-0003

Central and Atlantic Canada

In the past, Atlantic Canada and Quebec were not well connected to domestic crude oil production. Until recently, all of these Canadian refineries imported crude oil to meet their needs. With the reversal of Line 9 and more rail capacity, Quebec refineries now process some western Canadian crude oil and are less exposed to international crude oil market fluctuations.

Refineries in Newfoundland and Labrador and New Brunswick still rely almost entirely on imports, and at times process offshore eastern Canadian production. When it is economic to do so, the Irving refinery in New Brunswick rails crude oil from western Canada and the U.S. Because the refineries in Newfoundland and Labrador and New Brunswick import crude oil, they are more exposed to international crude oil market fluctuations.

Ontario

Ontario refineries process both western Canadian crude oil and imports. Almost 60% of the crude oil processed in Ontario is light crude. (Figure 14) Refining costs can be higher in Ontario due to this larger proportion of higher cost light crude, as well as added transportation costs given the distance between Sarnia and large producing areas.

Since the reversal of Line 9 back to its eastward flow, more crude oil has been sourced from the U.S. (Figure 15)

RPPs produced in Ontario are consumed in domestic regional markets. Three pipelines transport RPPs in Ontario: the Trans Northern Pipeline, the Sarnia Products Pipeline and the Sun Canadian Pipeline. The Trans Northern Pipeline transports RPPs from Quebec to locations in eastern Ontario and Toronto. The Sarnia Products Pipeline and the Sun Canadian Pipeline transport RPPs from Sarnia to Toronto. Ontario can also receive RPPs by rail, truck, and ship from Quebec and the U.S.

8 Due to confidentiality rules, Saskatchewan is not included. Average Year-to-Date July 2017.

FIGURE 13

Eastern Canada and Ontario - Refineries and Major Oil Transportation Routes

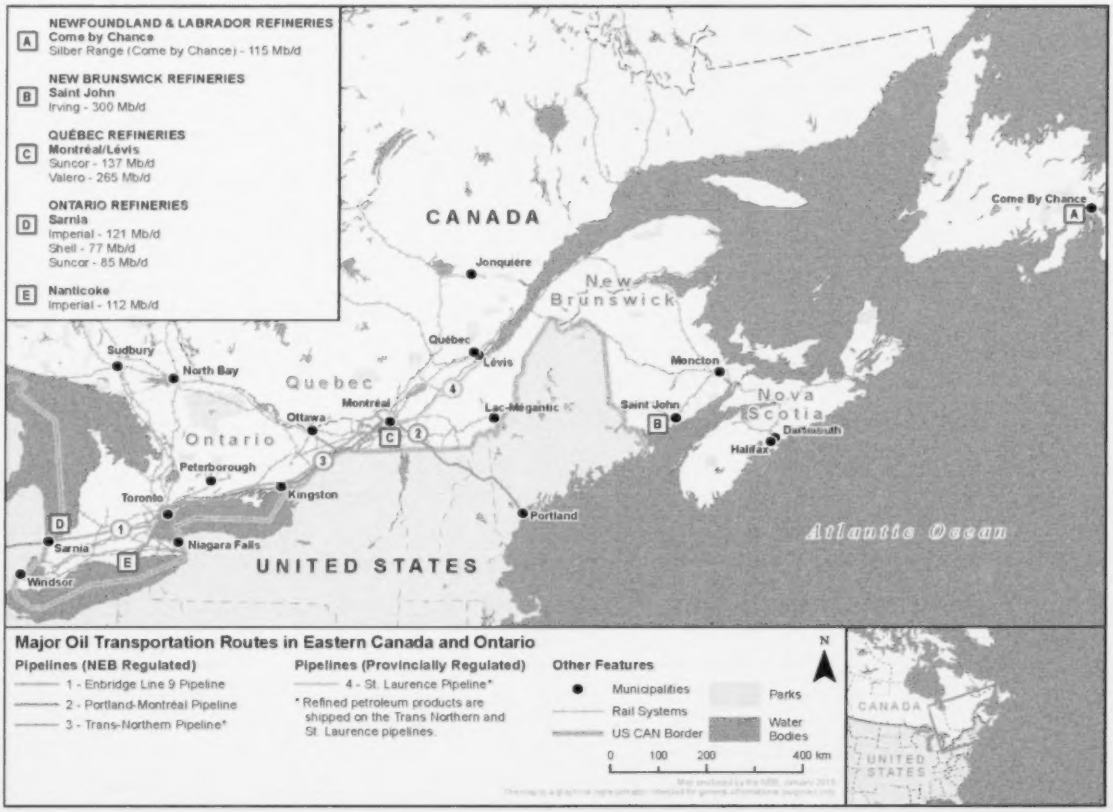
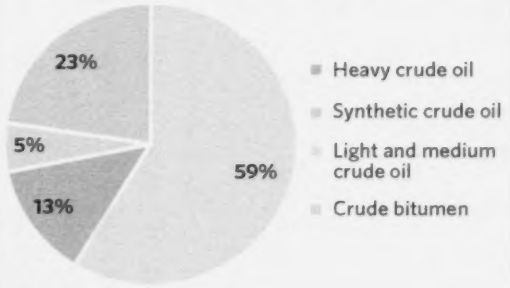


FIGURE 14

Input to Refineries by Crude Type – Ontario[9]

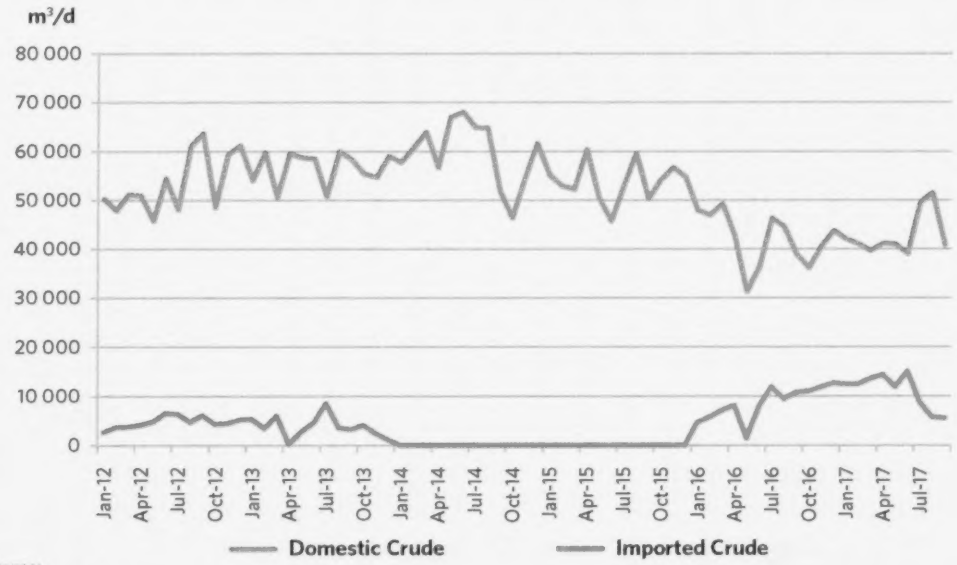


Source:
CANSIM 126-0003

9 Year-to-Date October 2017.

FIGURE 15

Western Canadian and Imported Crude Oil to Ontario Refineries



Source:
CANSIM 134-0001

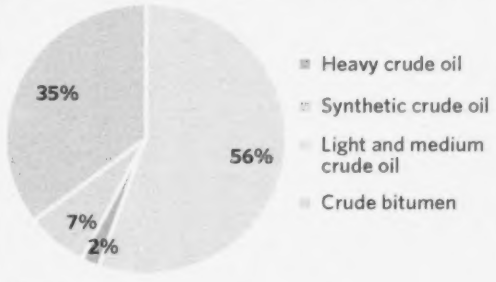
Quebec and Atlantic Canada

Access to tidewater allows refineries in Quebec and Atlantic Canada to have a more diverse crude oil supply than those in Ontario and western Canada, as well as access to markets for their RPP exports. In 2013, the Board approved the reversal and expansion of Line 9B, between North Westover, Ontario and Montreal, Quebec, so that crude oil could flow from west to east all the way to Montreal. This gave refineries in Quebec a pipeline connection to western Canadian and U.S. crude oil supply and reversed all of Line 9 to its original direction.

Quebec refineries process mostly light and medium crude oil with smaller volumes of synthetic and bitumen. (Figure 16)

FIGURE 16

Input to Refineries by Crude Type – Quebec[10]



Source:
CANSIM 126-0003

The Pipeline Saint-Laurent, links the Jean Gaulin Refinery operated by Valero in Lévis near Quebec City to the terminal in Montreal East, supplying the Greater Montreal area with large volumes of RPPs such as gasoline, diesel, heating, oil, and jet fuel. In addition, Trans Northern Pipeline transports RPPs from Quebec to Ontario.

Refineries located in Atlantic Canada almost exclusively rely on imported crude oil from a number of different countries supplemented with some east coast production. (Figure 17)

The Irving Refinery in Saint John, New Brunswick is the largest refinery in Canada, and exports considerable volumes of RPPs to the U.S. The Irving refinery is unique compared to refineries because it is a family-owned operation with no crude oil production, and a refining and marketing arm.

10 Due to confidentiality rules, only Quebec data is available.

Crude Oil Imports to Central and Eastern Canada

Eastern Canada imports significant volumes of crude oil to meet its refining needs. Each province, Newfoundland and Labrador, New Brunswick, Quebec, and Ontario has a diverse crude slate, with imports in some cases coming from several different countries.

In 2017, Newfoundland and Labrador received almost 60% of its crude oil from the U.S. This is down from 2015, when it received almost all of its imports from the U.S. It also imports crude oil from the United Kingdom and Angola.

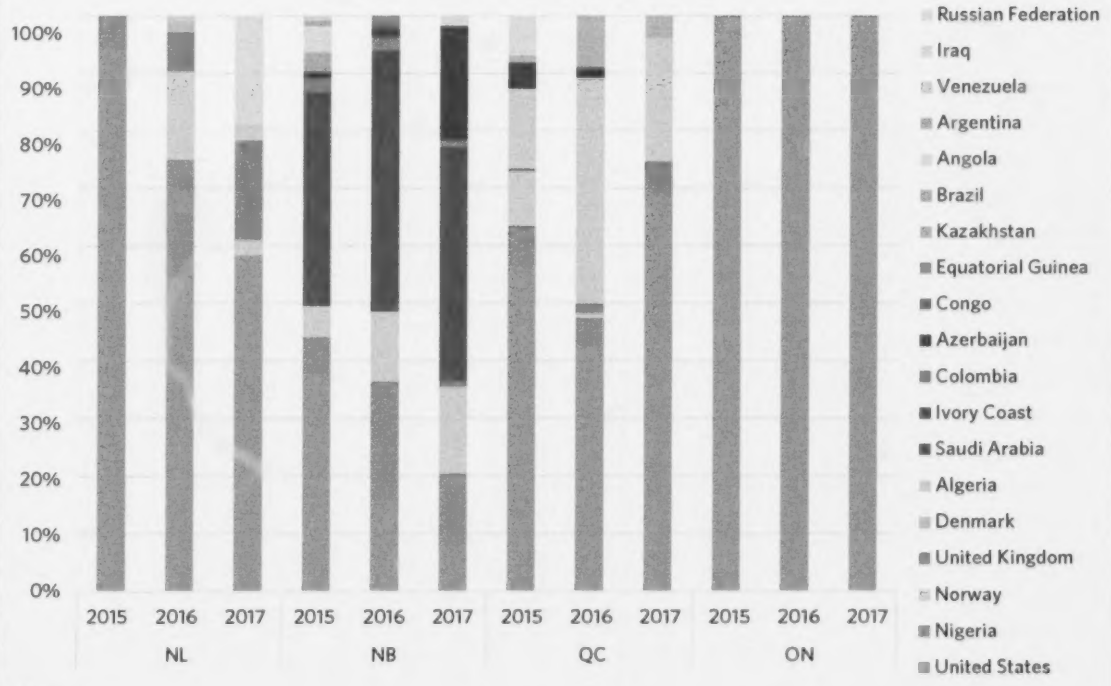
New Brunswick has the most diverse crude slate. In 2017[11], Saudi Arabia accounts for almost 40% of New Brunswick's crude oil imports, followed by Azerbaijan, the United Kingdom, the U.S., and Nigeria.

Quebec receives over 60% of its crude oil imports from the U.S. with lesser volumes from Algeria. U.S. imports have grown with the reversal of Line 9B.

Ontario receives all of its crude oil imports from the U.S. Most of the U.S. imports come from the states of Texas, North Dakota, and Indiana.

FIGURE 17

Imports by Eastern Canadian Provinces YTD 2017[12]



Source:
Statistics Canada's Canadian International Merchandise Trade Database

11 Year-To-Date to October 2017.
12 Year-To-Date October 2017.